

CLAIMS

5 What is claimed is:

1.Sequential diversity imaging apparatus comprising:

means for receiving a sequence of images of an object, said object
being continuously distorted by a changing optical medium;

10 an adaptive optic device in optical proximity with said receiving
means for canceling aberrations introduced by said medium to
thereby provide adapted images of said object;

a detector array arranged for receiving said adapted images and
producing digital image representations thereof; and

15 a sequential diversity processor connecting with said detector
array and said adaptive optic device, said sequential diversity
processor receiving said digital image representations from said
detector array and providing sequential control signals to said
adaptive optic device to enable said adaptive optic device to
cancel said aberrations.

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2. The sequential diversity imaging apparatus of Figure 1 wherein
said sequential diversity processor calculates a sequence of
diversities corresponding to said aberrations according to the
following diversities equation:

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$W(k) =$ unknown distorting wavefront at time k .

$T(k) =$ phase put on the AO at time k .

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$C(k) =$ compensated phase to be estimated by a
diversity algorithm $= W(k) + T(k)$ (1)

$I(k)$ = Measured image at time k .

$D(k)$ = Diversity phase.

Consider a diversity algorithm where $I(k-1)$ is the first image and

5 $I(k)$ is the diversity image. With this convention the diversity phase is the change in the AO phase from time $k-1$ to time k .

Thus,

$$D(k) = T(k) - T(k-1) \quad (2)$$

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The phase diversity algorithm is set up to estimate $C(k)$, the compensated phase at time k .

$$Q(k) = W1(k) + T(k) , \quad (3)$$

$$\text{set } T(k+1) = -W1(k) , \quad (4)$$

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Solving (3) for $W1(k)$ and substituting it into (4),

$$T(k+1) = -Q(k) + T(k) ,$$

$$T(k) = -Q(k-1) + T(k-1) .$$

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Insert equation (5) into (2) as follows,

$D(k) = (-Q(k-1) + T(k-1)) - T(k-1) = -Q(k-1)$ (6) to provide the specification for the diversity phase at time k .

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3. The sequential diversity imaging apparatus of Claim 2 wherein said control signals for said adaptive optic device are determined according to the following control equation:

$$30 \quad T(k) = T(k-1) + D(k) \quad (7) .$$

4. A method for determining aberrations caused by the atmosphere and controlling an adaptive optic device in an optical system to eliminate the aberrations comprising the steps of:
providing a plurality of images, each of said images having a
5 known diversity selected from the group consisting of phase, wavelength, or spatial shift;
determining an unknown object and parameters of said atmosphere causing said aberrations;
generating a plurality of sequential frames of a video recording
10 of said object to provide diversity images; and
inputting said diversity images to a sequential processor connected with said adaptive optic to thereby control said adaptive optic and eliminate said aberrations.
5. The method of Claim 4 wherein said wherein said sequential
15 diversity processor calculates a sequence of diversities corresponding to said aberrations according to the following diversities equation:

20 $W(k)$ = unknown distorting wavefront at time k .

$T(k)$ = Phase put on the AO at time k .

$C(k)$ = Compensated phase to be estimated by a
diversity algorithm = $W(k) + T(k)$ (1)

25 $I(k)$ = Measured image at time k .

$D(k)$ = Diversity phase.

The diversity phase is the change in the AO phase from time $k-1$ to
30 time k . Thus,

$D(k) = T(k) - T(k-1)$ (2)

The phase diversity algorithm is set up to estimate $C(k)$, the compensated phase at time k . Set the estimate $Q(k)$ from equation (1),

$$5 \quad Q(k) = W_1(k) + T(k), \quad (3)$$

where $W_1(k)$ is an estimate of $W(k)$, the unknown phase at time k . At time $k + 1$ the AO phase is set to the negative of the unknown wavefront at time $k+1$.

10 Set $T(k+1) = -W_1(k)$, where w_1 is the wavefront at time k (4)
Solving (3) for $W_1(k)$ and substituting it into (4),

$$T(k+1) = -Q(k) + T(k),$$

15 set $T(k) = -Q(k-1) + T(k-1)$.

Insert equation (5) into (2) to get

$$D(k) = (-Q(k-1) + T(k-1)) - T(k-1) = -Q(k-1) \quad (6)$$

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to provide the specification for the diversity phase at time k .

6. The method of Claim 5 wherein said control signals for said adaptive optic device are determined according to the following

25 control equation:

$$T(k) = T(k-1) + D(k) \quad (7).$$

Amended Claims Clean Version

1. Sequential diversity imaging apparatus comprising:
means for receiving a sequence of images of an object, said object being continuously distorted by a changing optical medium;
an adaptive optic device in optical proximity with said receiving means for canceling aberrations introduced by said medium to thereby provide solely adapted in-focus images of said object;
a detector array arranged for receiving said solely adapted in-focus images and producing digital image representations thereof; and
a sequential diversity processor connecting with said detector array and said adaptive optic device, said sequential diversity processor receiving said digital image representations from said detector array and providing sequential control signals to said adaptive optic device to enable said adaptive optic device to cancel said aberrations
2. The sequential diversity imaging apparatus of Claim 1 wherein said sequential diversity processor calculates a sequence of diversities corresponding to said aberrations according to a predetermined diversities equation
3. The sequential diversity imaging apparatus of Claim 2 wherein said control signals for said adaptive optic device are determined according to a predetermined control equation.

4. A method for determining aberrations caused by the atmosphere and controlling an adaptive optic device in an optical system to eliminate the aberrations comprising the steps of:

providing a plurality of solely in-focus images, each of said solely in-focus images having a known diversity selected from the group consisting of phase, wavelength, or spatial shift;

determining an unknown object and parameters of said atmosphere causing said aberrations;

generating a plurality of sequential frames of a video recording of said object to provide diversity images; and inputting said diversity images to a sequential processor connected with said adaptive optic to thereby control said adaptive optic and eliminate said aberrations.

5. The method of Claim 4 wherein said sequential diversity processor calculates a sequence of diversities corresponding to said aberrations according to a predetermined diversities equation.

6. The method of Claim 5 wherein said control signals for said adaptive optic device are determined according to a predetermined control equation

2. (amended) The sequential diversity imaging apparatus of [Figure] Claim 1 wherein said sequential diversity processor calculates a sequence of diversities corresponding to said aberrations according to [the following] a predetermined diversities equation [:]

[$W(k)$ = unknown distorting wavefront at time k .

$T(k)$ = phase put on the AO at time k .

$C(k)$ = compensated phase to be estimated by a diversity algorithm = $W(k) + T(k)$ (1)

$I(k)$ = Measured image at time k .

$D(k)$ = Diversity phase.

Consider a diversity algorithm where $I(k-1)$ is the first image and $I(k)$ is the diversity image. With this convention the diversity phase is the change in the AO phase from time $k-1$ to time k . Thus,

$$D(k) = T(k) - T(k-1) \quad (2)$$

The phase diversity algorithm is set up to estimate $C(k)$, the compensated phase at time k .

$$Q(k) = W1(k) + T(k) , \quad (3)$$

$$\text{set } T(k+1) = -W1(k) , \quad (4)$$

Solving (3) for $W1(k)$ and substituting it into (4),

$$T(k+1) = -Q(k) + T(k) ,$$

$$T(k) = -Q(k-1) + T(k-1) .$$

Insert equation (5) into (2) as follows,

$D(k) = (-Q(k-1) + T(k-1)) - T(k-1) = -Q(k-1)$ (6) to provide the specification for the diversity phase at time k.

3. (amended) The sequential diversity imaging apparatus of Claim 2 wherein said control signals for said adaptive optic device are determined according to [the following] a predetermined control equation:

$$T(k) = T(k-1) + D(k) \text{ (7).}]$$

4. (amended) A method for determining aberrations caused by the atmosphere and controlling an adaptive optic device in an optical system to eliminate the aberrations comprising the steps of:

providing a plurality of solely in-focus images, each of said solely in-focus images having a known diversity selected from the group consisting of phase, wavelength, or spatial shift;

determining an unknown object and parameters of said atmosphere causing said aberrations;

generating a plurality of sequential frames of a video recording of said object to provide diversity images; and inputting said diversity images to a sequential processor connected with said adaptive optic to thereby control said adaptive optic and eliminate said aberrations.

5. (amended) The method of Claim 4 wherein said [wherein said] sequential diversity processor calculates a sequence

of diversities corresponding to said aberrations according to [the following] a predetermined diversities equation[:]

$W(k)$ = unknown distorting wavefront at time k .

$T(k)$ = Phase put on the AO at time k .

$C(k)$ = Compensated phase to be estimated by a diversity algorithm = $W(k) + T(k)$ (1)

$I(k)$ = Measured image at time k .

$D(k)$ = Diversity phase.

The diversity phase is the change in the AO phase from time $k-1$ to time k . Thus,

$$D(k) = T(k) - T(k-1) \quad (2)$$

The phase diversity algorithm is set up to estimate $C(k)$, the compensated phase at time k . Set the estimate $Q(k)$ from equation (1),

$$Q(k) = W_1(k) + T(k) , \quad (3)$$

where $W_1(k)$ is an estimate of $W(k)$, the unknown phase at time k . At time $k+1$ the AO phase is set to the negative of the unknown wavefront at time $k+1$.

Set $T(k+1) = -W_1(k)$, where w_1 is the wavefront at time k (4)

Solving (3) for $W_1(k)$ and substituting it into (4),

$$T(k+1) = -Q(k) + T(k) ,$$